Synopsis

For

Ph.D.

Topic:

"Snake Diversity and Distribution in Jharkhand: A Comprehensive Ecological and Conservation Study"

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STATE OF THE ART

Introduction

Snakes are an ecologically significant group of reptiles, contributing to ecosystem stability through trophic interactions. Despite their importance, snake populations globally face threats due to habitat destruction and anthropogenic pressures[1]. India, with its remarkable herpetofaunal diversity, is home to over 362 snake species[2.] However, specific regional studies, such as those focusing on Jharkhand, remain sparse, underscoring the need for focused research on snake ecology, distribution, and conservation.

Global Context

Globally, herpetological research has documented approximately 4,175 recognized snake species inhabiting diverse ecological niches[47.] Tropical regions, characterized by habitat complexity and climatic stability, exhibit the highest snake diversity[3]. Studies have highlighted the ecological roles of snakes, including prey regulation and serving as prey for larger predators[4]. Iconic species like King Cobras and Pythons exemplify their ecological importance and conservation needs[5].

However, anthropogenic activities such as deforestation and urbanization have significantly impacted snake habitats, with global assessments revealing substantial extinction risks[6]. Additionally, climate change has influenced snake physiology, reproduction, and range shifts[7]. Modern tools, including artificial intelligence and telemetry, offer opportunities to study snake diversity and distributions more effectively[8].

Indian Context

India is a hotspot for herpetofaunal diversity, with regions such as the Western Ghats and the Eastern Himalayas contributing significantly to the discovery of new snake species[9,10]. Research has also explored the impacts of habitat fragmentation and human-wildlife conflict on snake populations, emphasizing the need for conservation-focused studies[11]. While several eastern states, including West Bengal and Odisha, have been surveyed, detailed snake-specific studies in Jharkhand remain limited[12,13].

Jharkhand Context

Jharkhand, with its varied topography and forested landscapes, has the potential to support high snake diversity. Preliminary studies in protected areas like Palamau Tiger Reserve and Dalma Wildlife Sanctuary have identified species such as the Cobra, Russell's Viper, Banded Krait[14]. However, systematic documentation of snake diversity and their ecological roles in the state is lacking. Factors such as mining and industrial activities contribute to habitat degradation, further threatening snake populations[7].

Ecological Importance of Snakes

As keystone species, snakes regulate prey populations, such as rodents, which can damage crops and spread disease[15]. Their ecological role extends to serving as prey for larger predators, maintaining trophic balance[16]. Additionally, venomous snakes contribute to advancements in pharmacology, with their venom being used for life-saving drugs[17].

Knowledge Gaps and Opportunities

Research in Jharkhand has primarily relied on anecdotal evidence or rescue records, with limited systematic studies[18]. Key questions include the current distribution of snake species, the effects of habitat modification, and the discovery of potentially new or endemic species[19]. Techniques such as molecular phylogenetics and radio telemetry can be applied to address these gaps[3].

Significance for Conservation

A comprehensive understanding of snake diversity in Jharkhand can inform conservation strategies and policy decisions. Integrating local communities into conservation efforts can reduce human-snake conflicts and foster coexistence, essential for habitat protection and ecological balance[20].

PROBLEM TO BE INVESTIGATED

Jharkhand's diverse landscapes support various snake species, yet significant gaps exist in research on their distribution, ecological roles, and threats, particularly in human-dominated environments. Urbanization, agriculture, and deforestation have disrupted habitats, causing increased human-snake conflict and often resulting in the killing or relocation of snakes due to fear or misinformation[21,22]. Despite some species being documented in protected areas like Palamau Tiger Reserve, a comprehensive survey of the state's snake populations is still lacking[23].

Habitat fragmentation, particularly in urban areas, exacerbates these conflicts[11], and the widespread perception of snakes as dangerous contributes to high rates of persecution[17]. The lack of detailed research leaves a critical knowledge gap regarding how human activities, such as urbanization and agriculture, affect snake populations in Jharkhand. These activities can lead to habitat loss, reduced prey availability, and increased conflicts[6,9].

The absence of effective mitigation strategies, such as public education on non-lethal methods of dealing with snakes, has hindered progress[17,24]. A state-wide study on snake distribution and ecology is needed to provide baseline data for conservation and to inform strategies for mitigating human-snake conflict[25].

Such research could guide land-use planning and policies to preserve snake habitats amidst urbanization and industrial growth[3]. Addressing these gaps in research is essential for the effective conservation of Jharkhand's snake fauna and promoting peaceful coexistence between humans and wildlife[27].

OBJECTIVES

1. To document and catalog the snake species found in Jharkhand.
2. To analyze the distribution patterns of these species across diverse habitats in the state.
3. To understand the ecological roles that snakes play within these habitats, particularly in human settlements.
4. To identify the major threats to snake populations, with a focus on human-snake conflicts.
5. To propose conservation measures and mitigation strategies to safeguard snakes in Jharkhand.

HYPOTHESIS

1. The snake species diversity in Jharkhand is underdocumented, with a wide variety of species distributed across different habitats in the state.
    - **Support:** This hypothesis is based on the general understanding that herpetofauna in India remains understudied, and there has been limited snake-specific research in Jharkhand[12,18].

2. The distribution of snake species in Jharkhand shows distinct patterns across different habitats, with a higher concentration of certain species in specific ecosystems, including urban and agricultural landscapes.
    - **Support:** This hypothesis aligns with ecological principles regarding species-habitat relationships[16,27].

3. Snakes play crucial ecological roles, especially in human settlements, by controlling rodent populations and maintaining ecological balance within urban and rural environments.
    - **Support:** This hypothesis aligns with the well-established ecological roles of snakes, particularly in pest control[26].

4. Human-snake conflicts, particularly in agricultural and urban areas, are the primary threats to snake populations in Jharkhand, leading to a decline in species diversity and distribution.
    - **Support:** This hypothesis is based on the recognized impacts of human activities, especially in the context of human-wildlife conflicts, on snake populations[22,28].

5. The implementation of effective conservation strategies, including conflict mitigation measures and habitat preservation, will significantly reduce human-snake conflicts and support the conservation of snake populations in Jharkhand.
    - **Support:** This hypothesis draws from a growing body of literature on the success of conflict mitigation and habitat preservation in wildlife conservation efforts[29,30].

RESEARCH DESIGN AND METHODOLOGY

Area Selection:

The study will be conducted across various habitats in Jharkhand, including forests, agricultural lands, grasslands, and urban settlements. The selection of survey sites will be random to ensure a diverse representation of snake species and their interactions across different landscapes. Random surveys are a well-established method for capturing a broad range of habitats, ensuring the collection of data from a variety of environments, which is crucial for understanding snake populations in both natural and human-dominated landscapes[22]. This approach will allow for more accurate insights into species distribution and human-snake interactions, especially in urban and agricultural settings, where such conflicts are common[11]. By surveying diverse areas, we aim to document the full spectrum of ecological roles and the potential threats faced by snake populations in Jharkhand.

Sampling Methods:

1. Visual Encounter Surveys (VES): These will be conducted during day and night, using standardized protocols to observe and document snake species[13,31].
2. Pitfall Traps: These traps will be employed to capture snakes for identification and further study[13].
3. Road Transects: Surveys along roads will document roadkill and live snake sightings, helping to assess the effects of human infrastructure on snake populations[32].
4. Any additional sampling methods recommended by experts or found necessary will be considered and applied as required.

Data Collection:

1. Species Documentation: Recording species, habitat, and behavior, including interactions with humans In addition to field surveys, data from snake rescues performed by the Forest Department, NGOs, and local snake rescuers will be integrated into the study. This will provide valuable insights into species distribution, especially in urban and human-dominated areas where direct observations might be limited[29].
2. Ecological Analysis: Studying habitat preferences, food sources, and predator-prey relationships[33].
3. Threat Assessment: Interviews with locals, field observations, and literature reviews to identify threats such as habitat destruction and human-wildlife conflict[11]. Additionally, a mobile app may be developed and utilized for recording snake species sightings as needed. This app will allow anyone—whether a member of the public, a forest official, or a local rescuer—to log snake sightings with details about species, location, and other relevant information. The app will serve as a tool for crowd-sourced data collection, helping to capture a wider range of snake observations and contribute to more comprehensive mapping of snake populations[34].
4. If other data collection methods are deemed necessary or recommended by experts, they will be adopted based on the project's needs.

STATISTICAL ANALYSIS

Data Analysis:

The collected data will be analyzed using statistical software such as SPSS and R to understand the distribution patterns and diversity of snake species across different habitats in Jharkhand. These tools will help in organizing and interpreting the large volumes of data gathered from field surveys, road transects, and other sampling methods.

Distribution Patterns Mapping:

The distribution of snake species across different habitat types (e.g., forests, agricultural lands, grasslands, and urban settlements) will be mapped using Geographic Information Systems (GIS) software. This approach facilitates the identification of spatial patterns and correlations between snake species and specific habitat characteristics. GIS tools are particularly useful for visualizing and analyzing spatial data[11], which is essential for understanding how snake populations are distributed across Jharkhand.

Diversity Indices:

Diversity indices such as the Shannon-Wiener Index and Simpson's Diversity Index will be used to assess species richness and abundance within different habitats. These indices will provide insights into how diverse the snake communities are and how evenly species are distributed[13,31].

The **Shannon-Wiener diversity index (H′)** is calculated using the formula:

$$H = -\Sigma [pi \times \ln(pi)]$$

where:

H: Shannon's diversity index,
ln: Natural log,
pi: The proportion of the entire community made up of species i

The formula for **Simpson's Diversity Index (D)** is:

$$D = \Sigma ni(ni-1) \ / \ N(N-1)$$

Where:

D: Simpson's diversity index,
ni: The number of individuals in a species,
N: The total number of individuals in the population

Species richness refers to the number of different species present in a given area, while abundance measures the number of individuals of each species. The use of diversity indices is crucial for understanding the ecological health of the regions studied and the relative importance of various snake species in maintaining ecosystem balance[12,18].

Statistical Testing:

Statistical tests such as Chi-square or ANOVA may be applied to determine if there are significant differences in snake species presence between habitats and to test hypotheses regarding human-snake conflict zones. If any new tools are developed in the future, they will also be utilized as per the requirement. These tests will be used to evaluate the effects of human activities, such as agriculture and urbanization, on snake populations[26,35].

Through these methods, the research will establish meaningful correlations between habitat features and snake diversity, enabling informed conservation efforts in Jharkhand[9,36].

TOOLS TO BE USED

1. Geographic Information Systems (GIS):

GIS will be employed for spatial analysis and to create distribution maps of snake species across Jharkhand. It is a powerful tool for mapping species distribution, identifying habitat preferences, and analyzing spatial patterns related to environmental factors. By integrating field data with geographical layers, GIS can help visualize snake distribution across various habitats, aiding in the identification of key areas for conservation and the mitigation of human-snake conflicts[37].

2. Statistical Software (e.g., SPSS, R):

Statistical analysis will be conducted using software such as SPSS and R to analyze ecological data and calculate diversity indices. These tools are essential for assessing species richness, evenness, and ecological diversity. Additionally, they will facilitate the comparison of snake populations across different habitats, identification of trends in species distribution, and interpretation of data in relation to environmental factors and human activity[9,25]. If other software is required, it may also be utilized for the analysis.

3. Field Equipment:

To ensure accurate data collection during surveys, the following field equipment will be used:

- **GPS Devices:** GPS devices will be utilized to record the precise locations of snake sightings and traps, aiding in the mapping of species distribution and ensuring repeatability of surveys in future studies[38].
- **Camera Trap Data:** Existing camera trap data collected by the Forest Department will be analyzed, providing valuable insights into the movement patterns and presence of snake species in different habitats without requiring additional field setup[3].
- **Snake Identification Guides:** Field guides will be employed for accurate identification of snake species encountered during surveys. These guides are crucial for distinguishing between species with similar morphological features, especially in regions with high snake diversity[39].
- **Expert-Recommended Tools:** If experts suggest the use of additional tools, they may be incorporated to enhance the efficiency and accuracy of data collection and analysis.

SIGNIFICANCE OF THE STUDY

This study is essential for understanding snake diversity, distribution, and ecological roles in Jharkhand, particularly within human settlements, where many snake species face increasing threats due to habitat loss and human-wildlife conflict[40,22].

1. Ecological Importance of Snakes:

- Snakes play a crucial role in maintaining ecosystem balance by regulating populations of rodents and other small animals. This contributes to pest control, benefiting agricultural practices by reducing crop-damaging rodents[41].
- The presence of snakes as top predators in their ecosystems is indicative of ecological health and biodiversity[6].

2. Addressing Human-Snake Conflicts:

- The study aims to tackle the increasing human-snake conflicts, which often result in negative consequences, such as snake killings, displacements, and snakebite incidents[28].
- Understanding the spatial distribution of snakes in relation to human settlements will enable the design of effective conservation strategies that protect both human safety and snake populations[45].

3. Identifying Threats to Snake Populations:

- Key threats such as habitat loss, fragmentation, and poisoning will be explored. Factors like deforestation, urbanization, and agricultural expansion are major drivers of species decline in Jharkhand, particularly in rural and peri-urban areas[10].
- Mitigating these threats is crucial for the survival of snake populations and the overall health of ecosystems[22].

4. Promoting Public Awareness and Education:

- Myths and fears about snakes often lead to their persecution. This study emphasizes the importance of public awareness and education to foster coexistence[27].
- Community-based conservation initiatives, such as training locals in snake identification and non-lethal handling methods, can reduce human-snake conflict and promote conservation[43].

5. Broader Conservation Implications:

- Conserving snake populations can also contribute to the protection of other wildlife species sharing the same habitats, reinforcing the interconnected nature of ecosystems[46].
- Snakes, as bioindicators, can provide insights into ecosystem health and the impacts of environmental changes[5].

The data generated from this study will guide effective conservation strategies that aim to balance the protection of snake populations and human interests. Promoting human-wildlife coexistence and addressing ecological challenges posed by human-snake interactions will contribute significantly to the long-term sustainability of snake populations and biodiversity conservation in Jharkhand.

CONTRIBUTION TO THE EXISTING KNOWLEDGE

This research will provide a detailed account of snake diversity and distribution in Jharkhand, focusing on human habitats. It will address gaps in regional herpetofaunal studies and offer new insights into the ecological roles of snakes in human-dominated landscapes. Snakes play a vital role in regulating small animal populations, contributing to ecosystem balance and pest control[16,18]. The study will examine interactions between snakes and human activities such as agriculture and urbanization, exploring their effects on both species and human communities[11, 43].

It will also highlight conservation challenges such as habitat loss, fragmentation, and poisoning due to human fear[28,42]. The findings will inform wildlife conservation efforts in Jharkhand, helping to formulate policies on biodiversity preservation and human-wildlife coexistence[43]. The study will suggest strategies for public awareness and education, emphasizing the role of local communities in managing human-snake conflict and preventing snakebites[43]. This research will promote a more informed, tolerant attitude toward snakes, which is crucial for their conservation[24].

In summary, this study will fill gaps in herpetofaunal knowledge and provide actionable insights for managing human-snake coexistence, with significant implications for wildlife management and conservation policies in Jharkhand[12,29].

FUTURE WORK

Future research should focus on long-term monitoring of snake populations in Jharkhand to assess the effectiveness of conservation measures, track population trends, and identify emerging threats[11,28]. The impact of urbanization, deforestation, and agricultural expansion on snake populations, particularly in conflict-prone areas, needs further investigation[44,45].

Community-based conservation programs will play a critical role in involving local populations in snake protection, awareness campaigns, and monitoring efforts to reduce persecution and promote sustainable human-snake relationships[43]. Training in non-lethal handling and relocation techniques will be key to the success of these programs[22].

Additional studies should explore the ecological effects of human-snake conflict, particularly concerning rodent populations and broader biodiversity[12,36]. Research on snakes role in pest regulation will highlight their ecological value and further support conservation efforts[18,42].

Future work should refine snake conservation strategies, focusing on habitat restoration, relocation programs, and wildlife corridors to prevent snakes from entering human settlements[28]. Research on venom's medical potential should also be encouraged for its broader applications in healthcare[43,5].

In conclusion, this research will provide critical insights to address human-snake conflicts in Jharkhand, informing policies and strategies that reduce snakebite incidents, protect snake populations, and promote peaceful coexistence[29].

References:

1. Gibbons, J. W., Scott, D. E., Ryan, T. J., Buhlmann, K. A., Tuberville, T. D., Metts, B. S., ... & Winne, C. T. (2000). The Global Decline of Reptiles, Déjà Vu Amphibians: Reptile species are declining on a global scale. Six significant threats to reptile populations are habitat loss and degradation, introduced invasive species, environmental pollution, disease, unsustainable use, and global climate change. BioScience, 50(8), 653-666.
2. Uetz, P., Freed, P., & Hošek, J. (Eds.). (2025a). The Reptile Database. Retrieved February 25, 2025, from https://reptile-database.reptarium.cz/advanced_search?taxon=snake&location=India&exact%5B0%5D=location&submit=Search
3. Harikrishnan, S., Ahmed, M. F., Das, A., Dutta, S. K., Giri, V., Mohapatra, P. P., ... & Shanker, K. (2022). A long-term monitoring programme to understand the impact of climate change on terrestrial herpetofauna of India. Hamadryad, 39(1).
4. Guedes, T. B., Nogueira, C., & Marques, O. A. (2014). Diversity, natural history, and geographic distribution of snakes in the Caatinga, Northeastern Brazil. Zootaxa, 3863(1), 1-93.
5. Brown, G. P., Madsen, T., Dubey, S., & Shine, R. (2017). The causes and ecological correlates of head scale asymmetry and fragmentation in a tropical snake. Scientific reports, 7(1), 11363.
6. França, R. C., & França, F. G. (2019). Spatial patterns of snake diversity in an urban area of north-east Brazil. Herpetological Journal, 29(4).
7. HARIKRISHNAN, S., MUDAPPA, D., & SHANKAR RAMAN, T. R. (2018). Herpetofaunal survey in rainforest remnants of the Western Ghats, India. Herpetological Bulletin, (146).
8. Bolon, I., Picek, L., Durso, A. M., Alcoba, G., Chappuis, F., & Ruiz de Castañeda, R. (2022). An artificial intelligence model to identify snakes from across the world: Opportunities and challenges for global health and herpetology. PLoS neglected tropical diseases, 16(8), e0010647.
9. Ganesh, S. R., Bhupathy, S., David, P., Sathishkumar, N., & Srinivas, G. (2014). SNAKE FAUNA OF HIGH WAVY MOUNTAINS, WESTERN GHATS, INDIA: SPECIES RICHNESS, STATUS, AND DISTRIBUTION PATTERN. Russian Journal of Herpetology, 21(1).
10. Das, A., Basu, D., Converse, L., & Su-resh, C. C. (2012). Herpetofauna of Katerniaghat Wildlife Sanctuary, Uttar Pradesh, India. Journal of Threatened Taxa, 4(5), 2553-2568.
11. Barhadiya, G., Purkayastha, J., Saha, A. K., & Ghosh, C. (2024). Spatial and temporal assessment of snake encounters in urban Delhi, India. Scientific Reports, 14(1), 5506.
12. Boruah, B., Das, A., Hussain, S. A., & Johnson, J. A. (2020). Assessment of Amphibian and Reptilian Diversity along Ganga River. Wildlife Institute of India-get paper here.
13. Das, A., Prasad, V.K., Murthy, S. (2019) Diversity and Ecology of Herpetofauna of Panna Tiger Reserve, Madhya Pradesh. Final Report, Wildlife Institute of India, Dehradun, 61pp.
14. Mallick, N. I. (2021). Wildlife in-situ conservation strategies in Jharkhand.
15. HODDLE, M. S. (2007). Biological control of vertebrate pests. Handbook of biological control, 955.
16. Greene, H. W. (1997). Snakes: the evolution of mystery in nature. Univ of California Press.

17. Litschka-Loen, T., Pons, J., Tiglao, P., Commandante, J., Santamaria, E., Sarmiento, M., ... & Harrison, R. (2019). RSTMH Special Report on Snakebite.
18. Das, A. (2016). Addition to the herpetofauna of Royal Manas National Park, Bhutan, with six new country records. Herpetology Notes, 9, 261-278.
19. Das, A., Gower, D., & Veerappan, D. (2020). Lost and found: rediscovery and systematics of the Northeast Indian snake Hebius pealii (Sclater, 1891). Vertebrate zoology, 70, 305-318.
20. Pandey, S. K., Kumar, A., Yadav, D. P., Sinha, A., Hassan, M. M., Singh, N. K., ... & Garg, N. (2023). Health evaluation and dangerous reptile detection using a novel framework powered by the YOLO algorithm to design high-content cellular imaging systems. The Journal of Engineering, 2023(12), e12335.
21. Das, A., Saikia, U., Murthy, B. H. C. K., Dey, S., & Dutta, S. K. (2009). A herpetofaunal inventory of Barail Wildlife Sanctuary and adjacent regions, Assam, north-eastern India. Hamadryad, 34(1), 117-134.
22. Kumar, N., Kumar, R., Chaudhary, A. K., & Mahto, T. (2020). Study of Incidence and Pattern of Snake Bite Cases Brought in Tertiary Care Hospital, Rims, Ranchi, Jharkhand. Indian Journal of Forensic Medicine & Toxicology, 14(4), 362-368.
23. Padhy, S. P., Vassa, C. N., Anand, D., Das, P., Jha, R. R., Das, A., & Gopi, G. V. (2024). Herpetofauna diversity in and around Gautam Buddha and Koderma Wildlife sanctuaries of Jharkhand, India. Herpetology Notes, 17, 639-652.
24. Malhotra, A., Wüster, W., Owens, J. B., Hodges, C. W., Jesudasan, A., Ch, G., ... & Murray, K. A. (2021). Promoting co-existence between humans and venomous snakes through increasing the herpetological knowledge base. Toxicon: X, 12, 100081.
25. Muliya, S. K., Nath, A., Kumar, G. C., Visvanathan, A., Selvan, M., Gowda, R., ... & Das, A. (2021). Addressing Wallacean shortfall using small sampling approach: a case study with endemic Lycodon flavicollis (Squamata: Colubridae) Mukherjee & Bhupathy, 2007. Journal of Asia-Pacific Biodiversity, 14(2), 159-168.
26. Luiselli, L., Sale, L., Akani, G. C., & Amori, G. (2020). Venomous snake abundance within snake species' assemblages worldwide. Diversity, 12(2), 69.
27. Harikrishnan, S., Chandramouli, S. R., & Vasudevan, K. A. R. T. H. I. K. E. Y. A. N. (2012). A survey of herpetofauna on Long Island, Andaman and Nicobar Islands, India. Herpetological Bulletin, 119(119), 19-28.
28. Kuttalam, S., Owens, J. B., Santra, V., Ahmed, M. T., Das, B., Das, S., ... & Malhotra, A. (2025). Utilising snake rescue data to understand snake–human conflict in Hooghly, West Bengal, India. Transactions of The Royal Society of Tropical Medicine and Hygiene, trae124.
29. Kuttalam, S., Santra, V., Owens, J. B., Selvan, M., Mukherjee, N., Graham, S., ... & Malhotra, A. (2022). Phylogenetic and morphological analysis of Gloydius himalayanus (Serpentes, Viperidae, Crotalinae), with the description of a new species. European journal of taxonomy, 852, 1-30.
30. Malhotra, A., Graham, S., Owens, J. B., Bharti, O., & Santra, V. (2022). Tackling Snakebite Through Training: an Indian example. Herpetological Conservation and Biology, 17(2), 331-342.
31. Banerjee, K., Nawani, S., Boruah, B., Habib, B., & Das, A. (2023). A rapid assessment of herpetofaunal diversity and mortality along a railway track in Northern Western Ghats, India: Herpetofaunal mortality on railway. Hamadryad, 40(1 and 2).

32. Owen, J. D., Meik, J. M., & Schwertner, T. W. (2015). Preliminary nocturnal road survey of snakes in northeastern Swaziland: Effects of agriculture on relative abundance. Herpetol. Rev, 46, 12-15.
33. Wasko, D. K., & Sasa, M. (2012). Food resources influence spatial ecology, habitat selection, and foraging behavior in an ambush-hunting snake (Viperidae: Bothrops asper): an experimental study. Zoology, 115(3), 179-187.
34. Howard, L., van Rees, C. B., Dahlquist, Z., Luikart, G., & Hand, B. K. (2022). A review of invasive species reporting apps for citizen science and opportunities for innovation. NeoBiota, 71, 165-188.
35. Guedes, T. B., Sawaya, R. J., Zizka, A., Laffan, S., Faurby, S., Pyron, R. A., ... & Antonelli, A. (2018). Patterns, biases and prospects in the distribution and diversity of Neotropical snakes. Global Ecology and Biogeography, 27(1), 14-21.
36. Longbottom, J., Shearer, F. M., Devine, M., Alcoba, G., Chappuis, F., Weiss, D. J., ... & Pigott, D. M. (2018). Vulnerability to snakebite envenoming: a global mapping of hotspots. The Lancet, 392(10148), 673-684.
37. Jenkins, C. L., Peterson, C. R., & Kingsbury, B. A. (2009). Modeling snake distribution and habitat. Snakes: ecology and conservation. Cornell University Press, Ithaca, New York, USA, 123-148.
38. D'Erchia, F., Getter, J., D'Erchia, T. D., Root, R., Stitt, S., & White, B. (1998). Geospatial technology applications and infrastructure in the Biological Resources Division (No. 1998-0001). US Geological Survey.
39. Whitaker, R. (2006). Common Indian snakes: a field guide. Macmillan.
40. Gureja, N., Kumar, A., & Saigal, S. (2019). Human-Wildlife Conflict in India. Report prepared for National Biodiversity Strategy and Action Plan (NBSAP), New Delhi.
41. Dinesh, G. K., Priyanka, B., Anokhe, A., Ramesh, P. T., Venkitachalam, R., Sri, K. K., ... & Soni, R. (2022). Ecosystem services and ecological role of birds in insect and pest control. Plant protection: from chemicals to biologicals, 1st edn. De Gruyter, Berlin, 623.
42. Hsiang, A. Y., Field, D. J., Webster, T. H., Behlke, A. D., Davis, M. B., Racicot, R. A., & Gauthier, J. A. (2015). The origin of snakes: revealing the ecology, behavior, and evolutionary history of early snakes using genomics, phenomics, and the fossil record. BMC evolutionary biology, 15, 1-22.
43. Bhaumik, S., Habib, A. G., & Santra, V. (2024). Strategic priorities for accelerating action to reduce the burden of snakebite. PLOS Global Public Health, 4(2), e0002866.
44. Deuti, K., Ganesh, S. R., & Chandra, K. (2022). Diversity, Distribution and Endemicity of Herpetofauna in Different Biogeographic Zones and Biodiversity Hotspots of India. In Biodiversity in India: Status, Issues and Challenges (pp. 119-148). Singapore: Springer Nature Singapore.
45. Jadhav, P. L., Chavan, S. P., & Trimukhe, H. S. (2018). Snake species diversity and their distribution in and around Nanded city, Maharashtra, India. Journal of Entomology and Zoology Studies, 6(4), 1855-1860.
46. Kalki, Y., Gonsalves, C., Wylie, D. B., Sundaram, K. A., & Schramer, T. D. (2021). Annotated checklist of the snakes of Bengaluru Urban District, Karnataka, India with notes on their natural history, distribution, and population trends over the last 150 years. Journal of Animal Diversity, 3(2), 26-41.
47. Uetz, P., Freed, P., & Hošek, J. (Eds.). (2025b). *The Reptile Database*. Retrieved February 25, 2025, from https://reptile-database.reptarium.cz/advanced_search?taxon=snake&submit=Search